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DECEW FALLS GS No. 1
EVALUATION OF HEADWORKS CONCRETE

Report No. 88-281-K

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ABSTRACT

Samples of concrete were obtained by drilling cores from the headworks piers of DeCew Falls GS No. 1. The condition and physical properties of the concrete were evaluated. A total of three cores were drilled, one from each of piers 4, 5 and 6.

The structure incorporated two types of concrete, old (1898) and new (1947). Both concretes, although non-air-entrained, are still in good condition. The average compressive strengths of the old and new concretes are 35.4 and 52.2 MPa, respectively. A further evaluation of the condition of the concrete should be conducted after the forebay is dewatered.

job	file	date	report no.
42-001-829	842.5 DEC	January 3, 1989	88-281-K

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DECEW FALLS GS No. 1
EVALUATION OF HEADWORKS CONCRETE

1.0 INTRODUCTION

At the request of the Civil Works Department, the Concrete Technology Section, Civil Research Department, conducted an investigation of the condition of the headworks concrete at DeCew Falls GS No. 1 between September 14 and 19, 1988. The investigation consisted of coring samples from the old (1898) and new (1947) concretes for laboratory testing and visual observation.

2.0 INVESTIGATIONS

2.1 Field

This portion of the investigation consisted of core drilling representative components of the headworks piers with a 100 mm nominal diameter bit vertically from the top of the deck.

The locations selected for coring are shown in Figure 1 and were chosen such that they were in close proximity to the proposed rehabilitation work. Cores 1 and 2 were drilled through the pier cap which protruded through the deck; Core 3 was drilled through the deck (485 mm depth) and into the pier.

For the purpose of identification, the piers are referred to as follows:

Pier 4 (Between Penstocks 4 and 5)
Pier 5 (Between Penstocks 5 and 6)
Pier 6 (Between Penstocks 6 and 7)

The cores from Piers 4 (Core 1), 6 (Core 2) and 5 (Core 3) were drilled to depths of approximately 2740, 3350 and 3660 mm, respectively. The cores as retrieved are shown in Figures 2, 3 and 4. The cores were recovered in sections and are identified, for example, as Core 1-3 for Core 1, Section 3.

A vertical construction joint (Figure 5) was intercepted at 2605 mm (Core 1-11) and further recovery of cores was not possible. Drilling was discontinued at this depth.

At all three core locations, the drill wash-water changed colour from cloudy white to light brown at the contact between the old and new concretes (Figure 6).

Detailed logs of Cores 1, 2 and 3 are attached as Appendix A.

2.2 Laboratory

The laboratory portion of the investigation consisted of selecting representative sections of the cores and testing in accordance with the applicable CSA and ASTM standards for the following properties:

Compressive Strength	CSA A23.2
Ultrasonic Pulse Velocity	ASTM C 597
Density and Absorption	ASTM C 642

A summary of the test results is given in Table 1.

3.0 OBSERVATIONS AND DISCUSSION

The cores were visually examined in the field as they were recovered and again in the laboratory (Appendix A). Each of the three cores distinctly depicted two different concretes. Both concretes were non-air-entrained. The new concrete (1947) extended from the top of the deck to approximately 2210 mm depth. Below this depth, old (1898) concrete was observed. The new concrete contains crushed aggregates, whereas in the old concrete, rounded gravel aggregates were noted. Both concretes generally appear to be in good condition.

In the new concrete, a horizontal construction joint was observed in all cores at approximately 1600 mm depth. A typical construction joint (Core 3) is illustrated in Figure 7. The maximum sizes of the aggregates in the cores representing the new concrete, above and below this joint, were 25 mm and 40 mm, respectively. The maximum size aggregate used in the old concrete was 50 mm.

None of the cores failed at the joint between the old and new concretes due to drilling forces during the drilling operation. A visual observation of this joint indicates that a good bond exists between the two concretes. Figure 8 shows a typical close-up view of the well bonded interface of the old and the new concretes.

A 10 mm steel plate embedded in the concrete (Figure 9) was observed at approximately 2515 mm depth in Cores 1 and 2. A steel angle, plate, and rivet (Figure 10) were observed at the same depth in Core 3.

A crack with leachate deposits along its surface (Figure 11) was observed at approximately the 2970 mm depth of Core 2.

Typical signs of deterioration of the concrete were noted on the top deck surface (Figure 12) where ravelling of the concrete has occurred. This deterioration of the surface is due to freeze-thaw action and is predominant in certain localized areas. Figure 13 shows the first section of Core 1 with the typical freeze-thaw deterioration cracks through the top portion of the core.

Although both concretes are considered to be in good condition, the new concrete is of better quality. The compressive strength of the new concrete (52.2 MPa) is significantly higher than the older concrete (35.4 MPa). The new concrete has a higher density and pulse velocity and a lower absorption than the old concrete and is likely more durable.

4.0 CONCLUSIONS AND RECOMMENDATION

Based on the visual inspection and the test results conducted, it is concluded that the concrete of the headworks piers is in good condition. Although both the new and the old concretes are in good condition, the new concrete is of better quality.

A further evaluation of the condition of the concrete should be conducted when the forebay is dewatered.

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TABLE 1

DeCew Falls GS No. 1
Evaluation of Headworks Concrete
Summary of Test Data

Core * Identification	Density (Kg/m^3)	Compressive Strength (MPa)	Ultrasonic Pulse Velocity (m/s)	Absorption (%)
1-3 +	2415	54.0	4950	5.1
1-7 +	2409	56.8	4830	4.0
1-9 +	2403	-	-	6.8
2-3 +	2372	46.2	4600	7.1
2-7 +	2397	47.1	4710	5.0
2-9 **	2285	-	-	6.5
2-11 **	2276	33.0	4210	-
2-13 **	2259	31.9	4130	8.0
3-6 +	2354	39.9	4600	6.5
3-8 +	2415	69.3	4950	3.9
3-13 **	2304	29.9	4400	6.8
3-14 **	2312	37.7	4400	-
3-15 **	2315	44.7	4500	6.3
Old Concrete				
- Range	2259 - 2315	29.9 - 44.7	4130 - 4500	6.3 - 8.0
- Avg.	2292	35.4	4328	6.9
New Concrete				
- Range	2354 - 2415	39.9 - 69.3	4600 - 4950	3.9 - 7.1
- Avg.	2395	52.2	4773	5.5

* Refer to core logs for locations. Core sections numbered from top of deck downwards.

** Old concrete (1898)
+ New Concrete (1947)

DeCew Falls GS No. 1
Evaluation of Headworks Concrete
Location of Cores

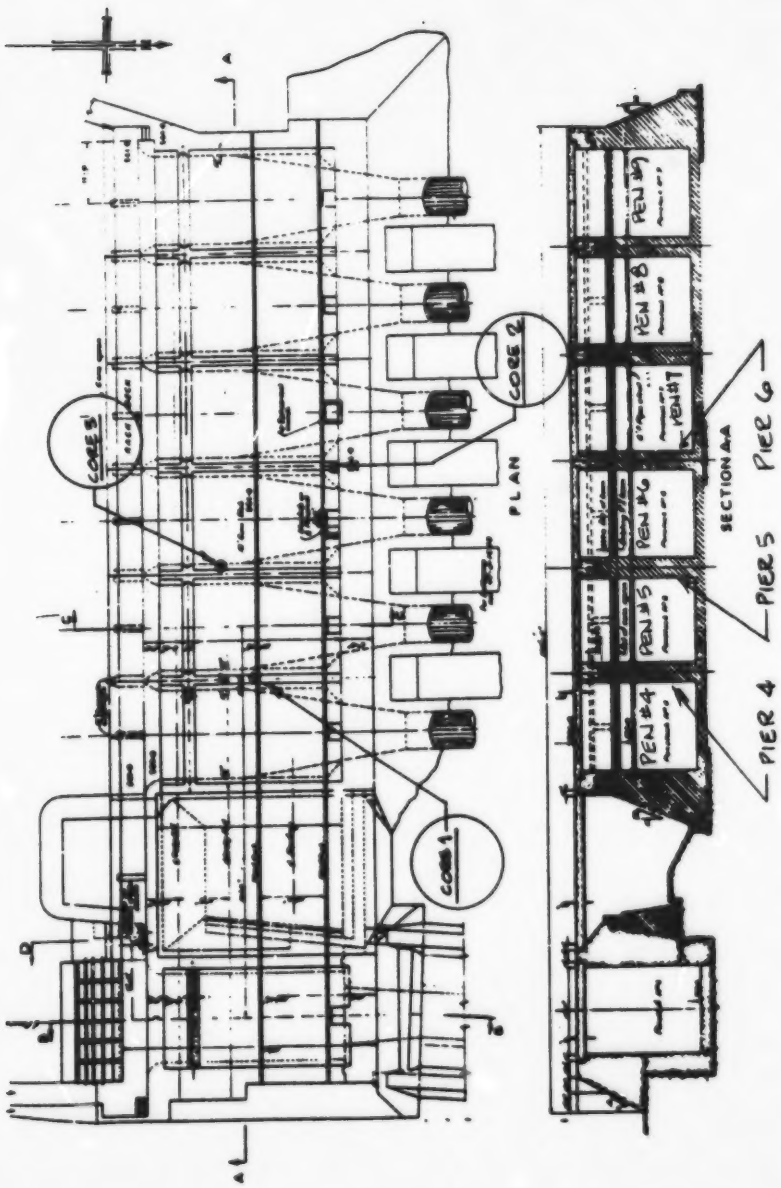

FIGURE 1

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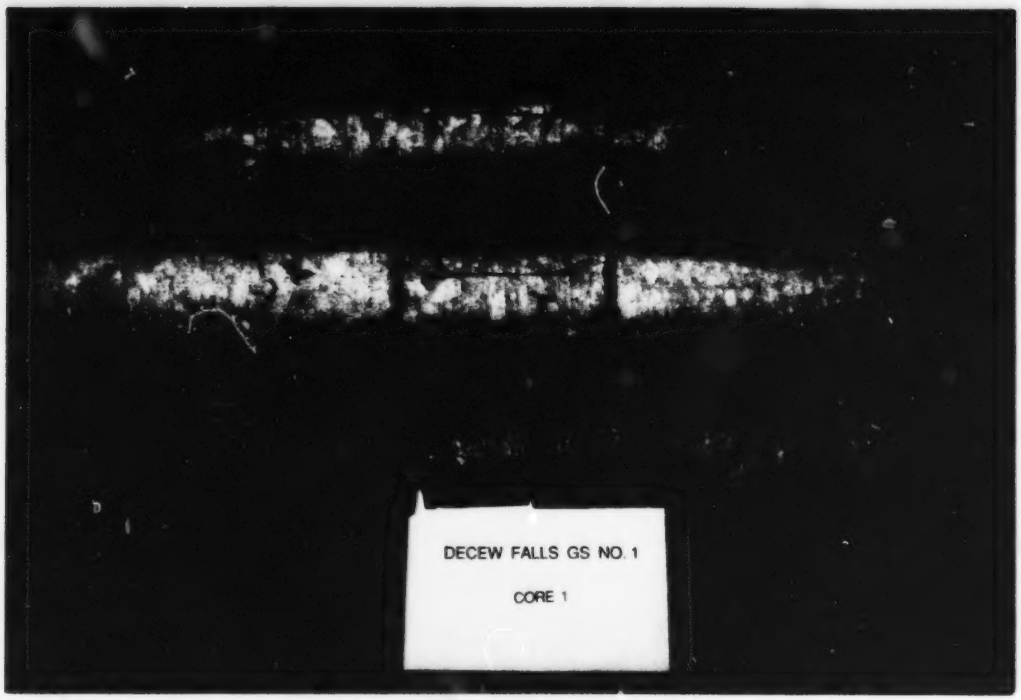

Figure 2: Core 1 (Note - Arrows point down from the top of the deck surface).

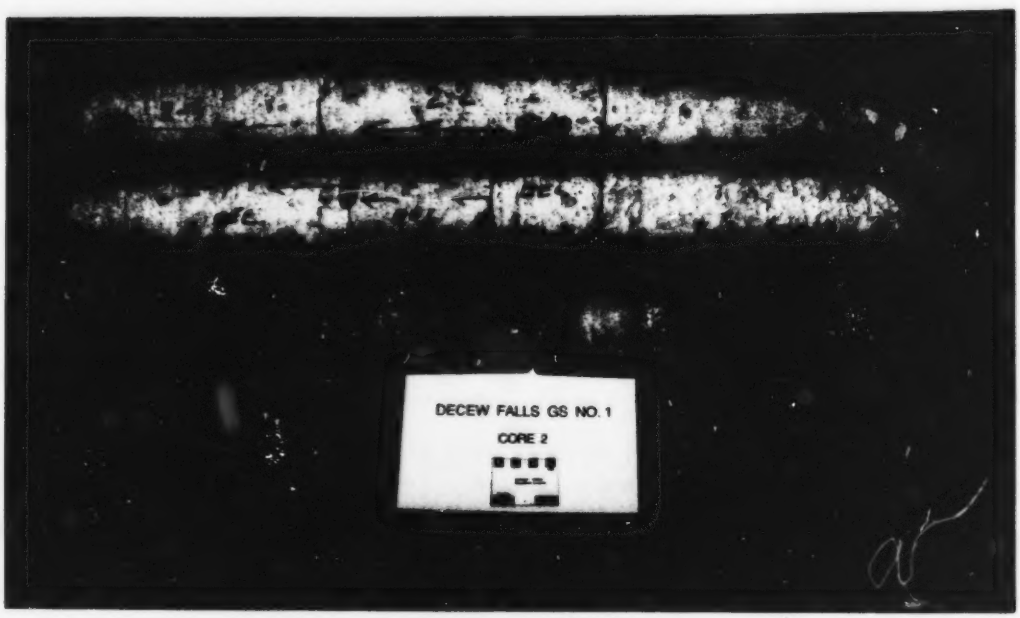

Figure 3: Core 2.

Figure 4: Core 3.

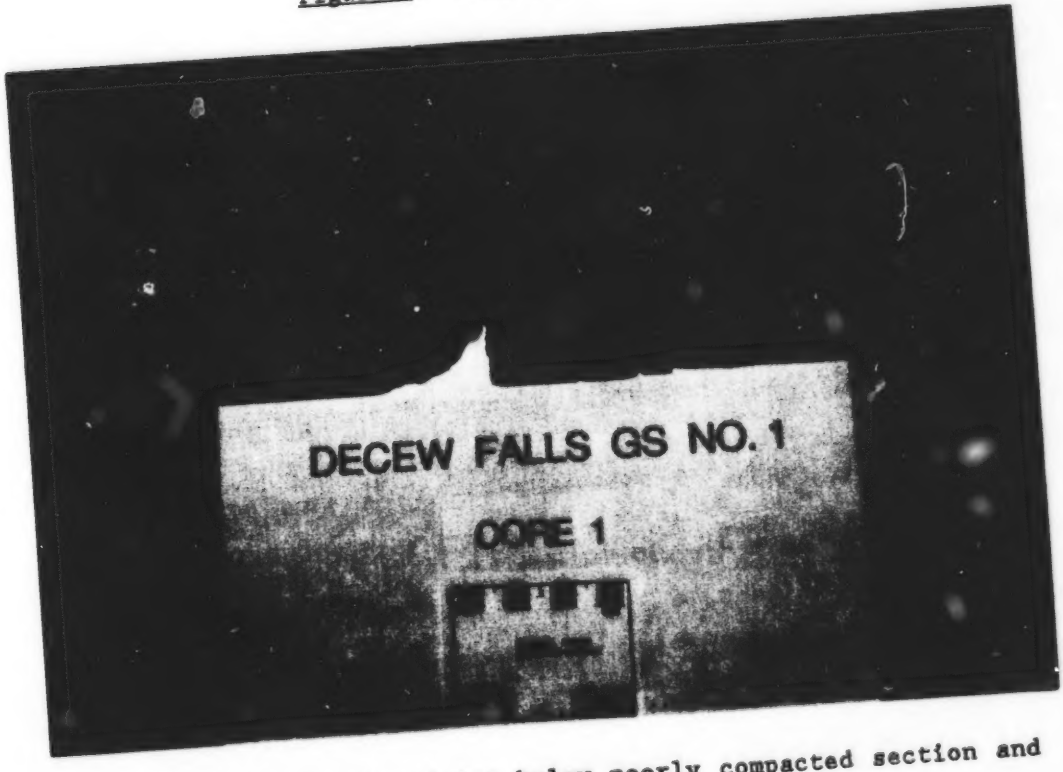

Figure 5: Vertical construction joint below poorly compacted section and steel plate.

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Figure 6: Drilling of Core 2. Note the light brown colour of wash-water at the interface between the new and old concretes.

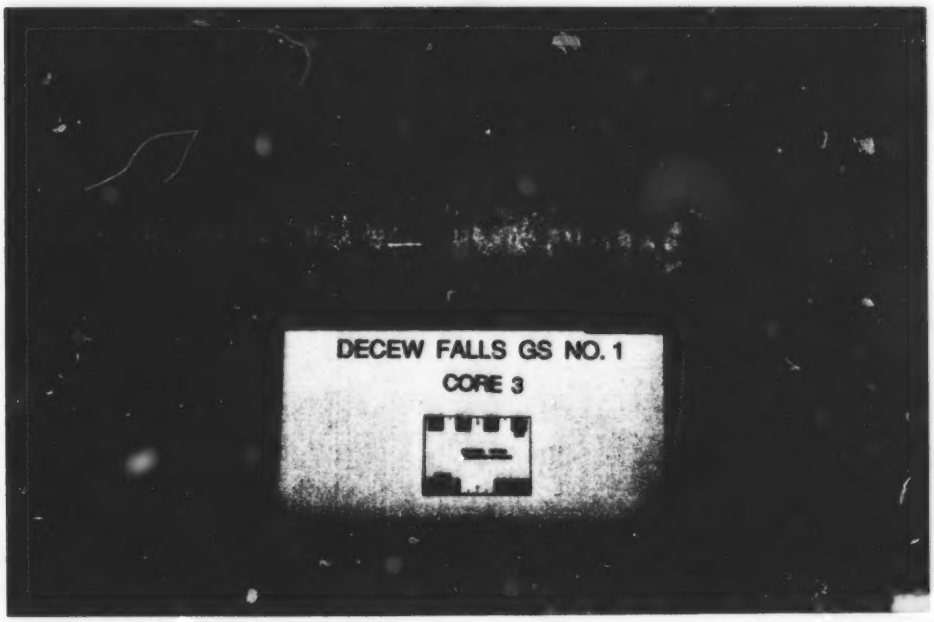

Figure 7: Typical construction joint between lifts of new concrete.

Figure 8: Typical contact between old and new concrete.

Figure 9: Typical steel plate embedded in the old concrete.

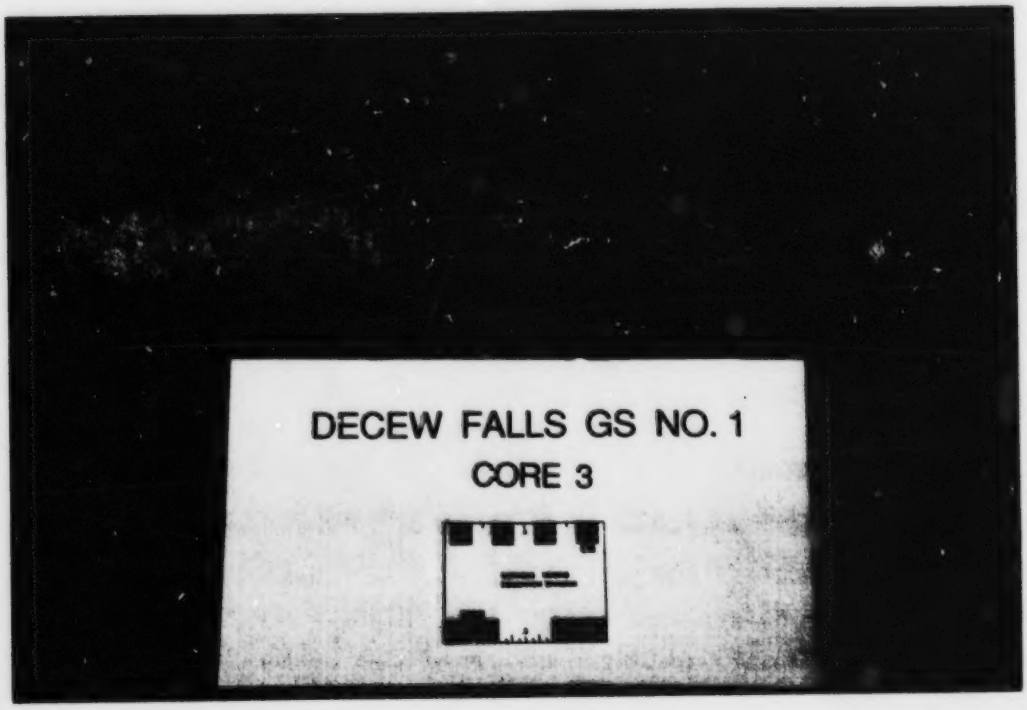

Figure 10: Steel rivet, 10 mm plate and angle embedded in old concrete.

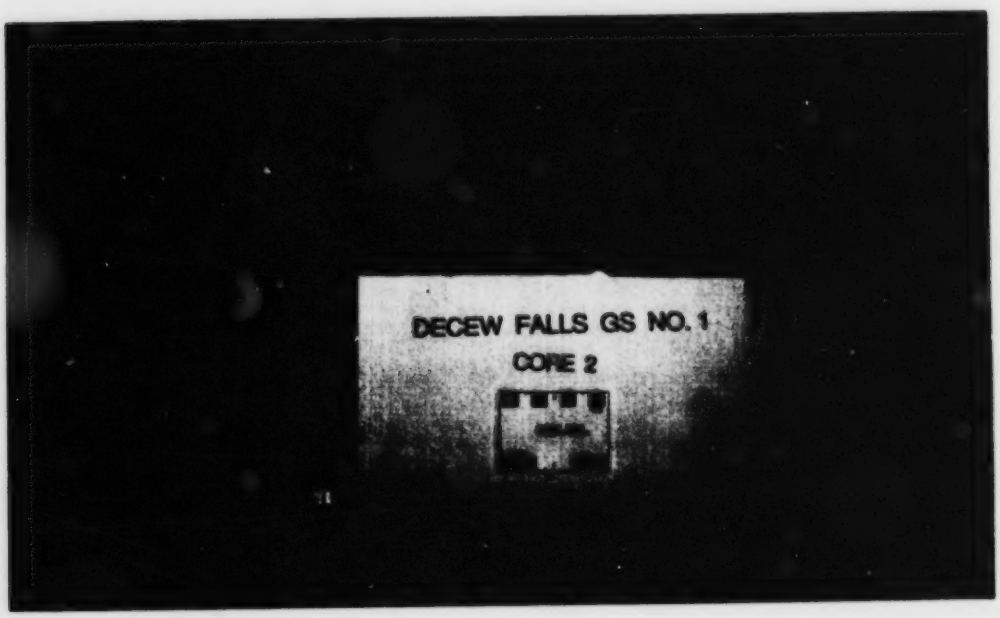

Figure 11: Crack with leachate deposits along its surface in Core 2 at 2970 mm depth.

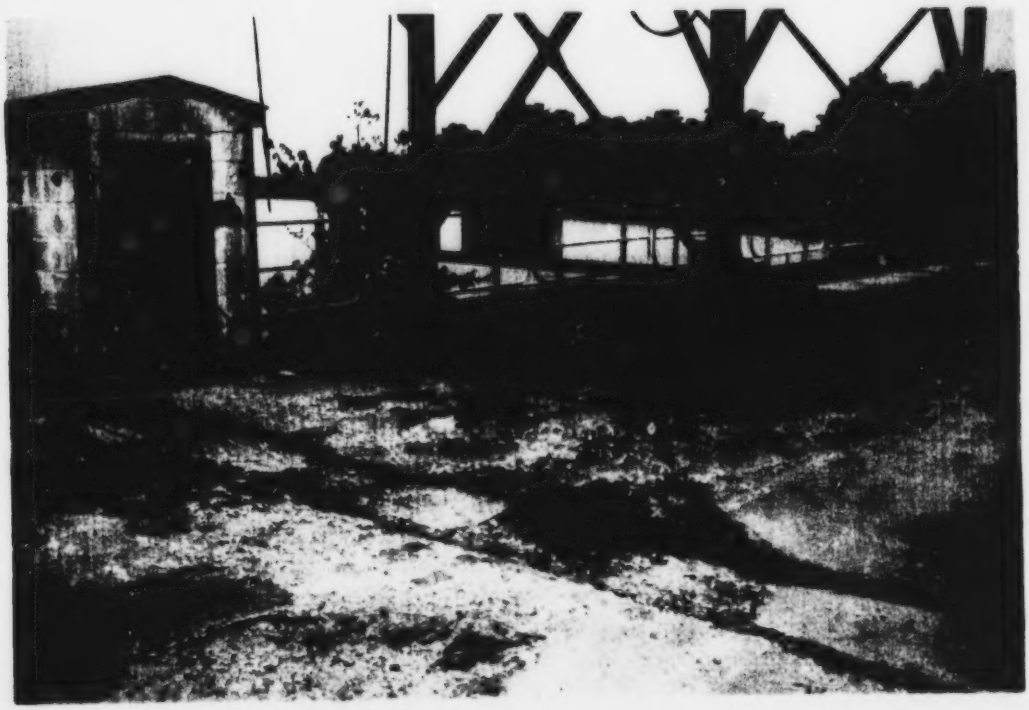

Figure 12: Typical deterioration of top surface of deck.

Figure 13: First section of Core 1 showing freeze-thaw damage. Note delamination in the top portion of core.

APPENDIX A

DECEW FALLS GS No. 1
EVALUATION OF HEADWORKS CONCRETE
CORE 1 LOG: PIER 4

Core Identification	Depth From-To (mm)	Description
-	0 - 50	- eroded away, possibly due to freeze-thaw damage
1-1	40 - 90	- freeze-thaw damage to 65 mm depth
1-2	90 - 345	- good concrete - max. aggregate size (crushed) 25 mm - good aggregate distribution
1-3	345 - 735	- good concrete
1-4	735 - 1055	- good concrete
1-5	1055 - 1370	- good concrete
1-6	1370 - 1600	- good concrete - construction joint at 1600 mm depth
1-7	1600 - 2020	- good concrete - max. aggregate size (crushed) 40 mm - good distribution of aggregate - some porous aggregate
1-8	2020 - 2250	- good concrete - good bond between new and old concretes at 2250 mm depth - bond remained intact during drilling - wash-water turned light brown upon drilling into old concrete
	2250 - 2410	- good concrete - old concrete (2250 mm depth); rounded aggregate with max. aggregate size 40 mm
1-9	2410 - 2530	- good concrete - max. aggregate size 50 mm - 10 mm steel plate at 2530 mm depth

APPENDIX A

DECEW FALLS GS No. 1
EVALUATION OF HEADWORKS CONCRETE
CORE 1 LOG: PIER 4

Core Identification	Depth From-To (mm)	Description
1-10	2530 - 2605	- poor concrete - poorly compacted concrete section - poor distribution of aggregate
1-11	2605 - 2800	- fair concrete - fair distribution of aggregate - core recovered revealed a vertical construction joint through its depth; the remaining half of the core could not be retrieved - drilling was discontinued

APPENDIX A

DECEW FALLS GS No. 1
EVALUATION OF HEADWORKS CONCRETE
CORE 2 LOG: PIER 6

Core Identification	Depth From-To (mm)	Description
2-1	0 - 405	- good concrete - max. aggregate size (crushed) 25 mm - good aggregate distribution - some porous aggregate
2-2	405 - 760	- good concrete
2-3	760 - 1065	- good concrete
2-4	1065 - 1475	- good concrete
2-5	1475 - 1600	- good concrete - steel cable at 1560 mm depth - construction joint at 1600 mm depth
2-6	1600 - 1780	- good concrete - max. aggregate size (crushed) 40 mm - good aggregate distribution - 20 mm reinforcing bar at 1780 mm depth
2-7	1780 - 2135	- good concrete
2-8	2135 - 2285	- good concrete (2135-2210 mm depth) - good bond between new and old concretes at 2210 mm depth - bond remained intact during drilling - water turned light brown upon drilling into old concrete - older concrete (2210 mm depth); rounded aggregate, max. size aggregate 25 mm
2-9	2285 - 2515	- good concrete, some voids - max. size aggregate 45 mm - fair distribution of aggregate

APPENDIX A

DECEW FALLS GS No. 1
EVALUATION OF HEADWORKS CONCRETE
CORE 2 LOG: PIER 6

Core Identification	Depth From-To (mm)	Description
2-9 (con't.)	2285 - 2515	- 10 mm steel plate at 2515 mm depth
2-10	2515 - 2680	- good concrete - max. size aggregate 50 mm
2-11	2680 - 2920	- good concrete - crack at 2920 mm depth
2-12	2920 - 2970	- fair concrete - crack with leachate deposit at 2970 mm depth
2-13	2970 - 3300	- good concrete

APPENDIX A
DECEW FALLS GS No. 1
EVALUATION OF HEADWORKS CONCRETE
CORE 3 LOG: PIER 5

Core Identification	Depth From-To (mm)	Description
3-1	0 - 230	- good concrete - max. aggregate size (crushed) 25 mm - good distribution of aggregate - reinforcing bar (25 mm) at 205 mm depth
3-2	230 - 305	- good concrete - reinforcing bar at 280 mm depth
3-3	305 - 485	- good concrete - reinforcing bar at 420 mm depth - bottom of core (485 mm depth) coated with bitumen (deck seat on the pier)
3-4	485 - 710	- good concrete
3-5	710 - 1065	- good concrete
3-6	1065 - 1400	- good concrete
3-7	1400 - 1615	- good concrete - construction joint at 1615 mm depth
3-8	1615 - 1995	- good concrete - max. aggregate size (crushed) 40 mm - good distribution of aggregate - some porous aggregate
3-9	1995 - 2260	- good concrete (1995 - 2225 mm depth) - good bond between new and old concretes at 2225 mm depth - bond remained intact after recovery - wash water turned light brown upon drilling into old concrete

APPENDIX A
DECEW FALLS GS No. 1
EVALUATION OF HEADWORKS CONCRETE
CORE 3 LOG: PIER 5

Core Identification	Depth From-To (mm)	Description
3-9 (con't.)	1995 - 2260	- old concrete (>2225 mm depth); rounded aggregate, max. size aggregate 25 mm
3-10	2260 - 2390	- good concrete - fair aggregate distribution
3-11	2390 - 2540	- good concrete - at 2515 mm depth drilled through a rivet, 10 mm steel plate, and a 10 mm angle which extended to 2630 mm depth
3-12	2540 - 2780	- good concrete - small poorly compacted section directly underneath the angle - the steel angle overlaps both cores (3-11 and 3-12)
3-13	2780 - 3075	- good concrete - max. size aggregate 50 mm
3-14	3075 - 3300	- good concrete - suspected construction joint with laitance deposits at 3300 mm depth
3-15	3300 - 3660	- good concrete